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EE 318 062 10505
June 8, 2000
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Docket No. AUS990939US1

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Transmitted herewith for filing is the patent application of Inventor(s):

RICHARD LOUIS ARNDTFor: **HYPERVERSOR FUNCTION SETS**

Enclosed are also:

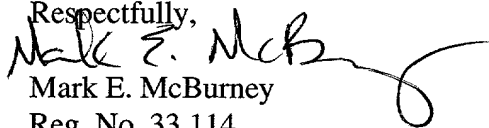
- ☒ 24 Pages of Specification including an Abstract
☒ 6 Pages of Claims
☒ 7 Sheet(s) of Drawings
☒ A Declaration and Power of Attorney
☒ Form PTO 1595 and assignment of the invention to IBM Corporation

CLAIMS AS FILED

FOR	Number Filed		Number Extra		Rate		Basic Fee (\$690)
Total Claims	24	-20 =	4	X	\$ 18	=	\$ 72.00
Independent Claims	4	-3 =	1	X	\$ 78	=	\$ 78.00
Multiple Dependent Claims	0			X	\$260	=	\$ 0.00
Total Filing Fee							= \$ 840.00

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JC828 U.S. PTO
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HYPERVISOR FUNCTION SETS

BACKGROUND OF THE INVENTION

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Cross Reference to Related Applications

The present application is related to co-pending
U.S. Patent Application Serial No. _____ (IBM
10 Docket No. AUS990940US1) entitled "HYPERVISOR AS A SET OF
SERVICES" filed _____ and to U.S. Patent
Application Serial No. _____ (IBM Docket No.
AUS990941US1) entitled "DMA WINDOWING" filed
_____. The content of the above-mentioned
15 commonly assigned, co-pending U.S. Patent applications
are hereby incorporated herein by reference for all
purposes.

1. Technical Field:

20 The present invention relates generally to the field
of computer architecture and, more specifically, to
methods and systems for managing resources among multiple
operating system images within a logically partitioned
data processing system.

25

2. Description of Related Art:

A logical partitioning option (LPAR) within a data
processing system (platform) allows multiple copies of a
single operating system (OS) or multiple heterogeneous
30 operating systems to be simultaneously run on a single
data processing system platform. A partition, within

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which an operating system image runs, is assigned a non-overlapping sub-set of the platform's resources. These platform allocable resources include one or more architecturally distinct processors with their interrupt
5 management area, regions of system memory, and I/O adapter bus slots. The partition's resources are represented by its own open firmware device tree to the OS image.

Each distinct OS or image of an OS running within
10 the platform are protected from each other such that software errors on one logical partition cannot affect the correct operation of any of the other partitions. This is provided by allocating a disjoint set of platform resources to be directly managed by each OS image and by
15 providing mechanisms for ensuring that the various images cannot control any resources that have not been allocated to it. Furthermore, software errors in the control of an OS's allocated resources are prevented from affecting the resources of any other image. Thus, each image of the OS
20 (or each different OS) directly controls a distinct set of allocable resources within the platform.

One method that has been developed to create and maintain separation between the partitions within the data processing system is the use of a firmware component
25 referred to as a hypervisor in the RS/6000 data processing system. The RS/6000 is a product and trademark of International Business Machines Corporation of Armonk, New York. This firmware component performs many functions and services for the various operating
30 system images running within the logically partitioned data processing system.

As the software and hardware are improved over time, the library of services offered by the firmware component expands. The OS images must be made aware of these changes. Furthermore, as various options are selected by various implementations, or options are enabled or disabled by user policy, the OS images must also be made aware of these changes as well. Currently, there is no method for providing this information to the various OS images such that they are aware of which functions are available from the firmware component on a given platform at a given time. Thus, it is desirable to have a mechanism for making the OS images within a logically partitioned system aware of which functions are available to it through the firmware component.

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SUMMARY OF THE INVENTION

5 The present invention provides a method, system, and apparatus for informing a plurality of operating systems, each assigned to a separate partition within a logically partitioned data processing system, of which functions, provided by a hypervisor for creating and enforcing
10 separation of the logical partitions, are available for use by the operating systems. In a preferred embodiment, the hypervisor includes a plurality of function sets. Each function set includes a list of functions, that may be called by any one of the operating systems to perform
15 tasks for the operating systems while maintaining separation between each of the logical partitions. The hypervisor informs each of the plurality of operating systems of an enabled function set. Functions identified within the enabled function set are enabled for use by
20 each of the plurality of operating systems and functions not identified within the enabled function set are disabled for use by each of the plurality of operating systems.

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BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the
5 invention are set forth in the appended claims. The
invention itself, however, as well as a preferred mode of
use, further objectives and advantages thereof, will best
be understood by reference to the following detailed
description of an illustrative embodiment when read in
10 conjunction with the accompanying drawings, wherein:

Figure 1 depicts a pictorial representation of a
distributed data processing system in which the present
invention may be implemented;

Figure 2, a block diagram of a data processing
15 system in accordance with the present invention is
illustrated;

Figure 3 depicts a block diagram of a data
processing system, which may be implemented as a
logically partitioned server, in accordance with the
20 present invention;

Figure 4 depicts a block diagram of a logically
partitioned platform in which the present invention may
be implemented;

Figure 5 depicts an exemplary hypervisor function
25 set table in accordance with the present invention;

Figure 6 depicts a flowchart illustrating an
exemplary process for providing an operating system with
a list of hypervisor function calls available on a
platform in accordance with the present invention; and

30 **Figure 7** depicts a flowchart illustrating an
exemplary method for updating a list of function sets

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within a platform in accordance with the present invention.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

5 With reference now to the figures, and in particular with reference to **Figure 1**, a pictorial representation of a distributed data processing system is depicted in which the present invention may be implemented.

10 Distributed data processing system **100** is a network of computers in which the present invention may be implemented. Distributed data processing system **100** contains network **102**, which is the medium used to provide communications links between various devices and computers connected within distributed data processing
15 system **100**. Network **102** may include permanent connections, such as wire or fiber optic cables, or temporary connections made through telephone connections.

20 In the depicted example, server **104** is connected to hardware system console **150**. Server **104** is also connected to network **102**, along with storage unit **106**. In addition, clients **108**, **110** and **112** are also connected to network **102**. These clients, **108**, **110** and **112**, may be, for example, personal computers or network computers. For purposes of this application, a network computer is
25 any computer coupled to a network that receives a program or other application from another computer coupled to the network. In the depicted example, server **104** is a logically partitioned platform and provides data, such as boot files, operating system images and applications, to
30 clients **108-112**. Hardware system console **150** may be a laptop computer and is used to display messages to an

operator from each operating system image running on server **104**, as well as to send input information, received from the operator, to server **104**. Clients **108**, **110** and **112** are clients to server **104**. Distributed data processing system **100** may include additional servers, clients, and other devices not shown. Distributed data processing system **100** also includes printers **114**, **116** and **118**. A client, such as client **110**, may print directly to printer **114**. Clients, such as client **108** and client **112**, do not have directly attached printers. These clients may print to printer **116**, which is attached to server **104**, or to printer **118**, which is a network printer that does not require connection to a computer for printing documents. Client **110**, alternatively, may print to printer **116** or printer **118**, depending on the printer type and the document requirements.

Figure 1 is intended as an example and not as an architectural limitation for the processes of the present

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invention.

With reference now to **Figure 2**, a block diagram of a data processing system in accordance with the present invention is illustrated. Data processing system **200** is an example of a hardware system console, such as hardware system console **150** depicted in **Figure 1**. Data processing system **200** employs a peripheral component interconnect (PCI) local bus architecture. Although the depicted example employs a PCI bus, other bus architectures, such as Micro Channel and ISA, may be used. Processor **202** and main memory **204** are connected to PCI local bus **206** through PCI bridge **208**. PCI bridge **208** may also include an integrated memory controller and cache memory for processor **202**. Additional connections to PCI local bus **206** may be made through direct component interconnection or through add-in boards. In the depicted example, local area network (LAN) adapter **210**, SCSI host bus adapter **212**, and expansion bus interface **214** are connected to PCI local bus **206** by direct component connection. In contrast, audio adapter **216**, graphics adapter **218**, and audio/video adapter (A/V) **219** are connected to PCI local bus **206** by add-in boards inserted into expansion slots. Expansion bus interface **214** provides a connection for a keyboard and mouse adapter **220**, modem **222**, and additional memory **224**. In the depicted example, SCSI host bus adapter **212** provides a connection for hard disk drive **226**, tape drive **228**, CD-ROM drive **230**, and digital video disc read only memory drive (DVD-ROM) **232**. Typical PCI local bus implementations will support three or four PCI expansion slots or add-in connectors.

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An operating system runs on processor **202** and is used to coordinate and provide control of various components within data processing system **200** in **Figure 2**. The operating system may be a commercially available
5 operating system, such as OS/2, which is available from International Business Machines Corporation. "OS/2" is a trademark of International Business Machines Corporation. An object-oriented programming system, such as Java, may run in conjunction with the operating system, providing
10 calls to the operating system from Java programs or applications executing on data processing system **200**. Instructions for the operating system, the object-oriented operating system, and applications or programs are located on a storage device, such as hard
15 disk drive **226**, and may be loaded into main memory **204** for execution by processor **202**.

Those of ordinary skill in the art will appreciate that the hardware in **Figure 2** may vary depending on the implementation. For example, other peripheral devices,
20 such as optical disk drives and the like, may be used in addition to or in place of the hardware depicted in **Figure 2**. The depicted example is not meant to imply architectural limitations with respect to the present invention. For example, the processes of the present
25 invention may be applied to multiprocessor data processing systems.

With reference now to **Figure 3**, a block diagram of a data processing system, which may be implemented as a logically partitioned server, such as server **104** in
30 **Figure 1**, is depicted in accordance with the present invention. Data processing system **300** may be a symmetric

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multiprocessor (SMP) system including a plurality of processors **301**, **302**, **303**, and **304** connected to system bus **306**. For example, data processing system **300** may be an IBM RS/6000, a product of International Business Machines Corporation in Armonk, New York. Alternatively, a single processor system may be employed. Also connected to system bus **306** is memory controller/cache **308**, which provides an interface to a plurality of local memories **360-363**. I/O bus bridge **310** is connected to system bus **306** and provides an interface to I/O bus **312**. Memory controller/cache **308** and I/O bus bridge **310** may be integrated as depicted.

Data processing system **300** is a logically partitioned data processing system. Thus, data processing system **300** may have multiple heterogeneous operating systems (or multiple instances of a single operating system) running simultaneously. Each of these multiple operating systems may have any number of software programs executing within it. Data processing system **300** is logically partitioned such that different I/O adapters **320-321**, **328-329**, **336-337**, and **346-347** may be assigned to different logical partitions.

Thus, for example, suppose data processing system **300** is divided into three logical partitions, P1, P2, and P3. Each of I/O adapters **320-321**, **328-329**, and **336-337**, each of processors **301-304**, and each of local memories **360-364** is assigned to one of the three partitions. For example, processor **301**, memory **360**, and I/O adapters **320**, **328**, and **329** may be assigned to logical partition P1; processors **302-303**, memory **361**, and I/O adapters **321** and

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337 may be assigned to partition P2; and processor **304**, memories **362-363**, and I/O adapters **336** and **346-347** may be assigned to logical partition P3.

Each operating system executing within data processing system **300** is assigned to a different logical partition. Thus, each operating system executing within data processing system **300** may access only those I/O units that are within its logical partition. Thus, for example, one instance of the Advanced Interactive Executive (AIX) operating system may be executing within partition P1, a second instance (image) of the AIX operating system may be executing within partition P2, and a Windows 2000™ operating system may be operating within logical partition P1. Windows 2000 is a product and trademark of Microsoft Corporation of Redmond, Washington.

Peripheral component interconnect (PCI) Host bridge **314** connected to I/O bus **312** provides an interface to PCI local bus **315**. A number of Terminal Bridges **316-317** may be connected to PCI bus **315**. Typical PCI bus implementations will support four Terminal Bridges for providing expansion slots or add-in connectors. Each of Terminal Bridges **316-317** is connected to a PCI/I/O Adapter **320-321** through a PCI Bus **318-319**. Each I/O Adapter **320-321** provides an interface between data processing system **300** and input/output devices such as, for example, other network computers, which are clients to server **300**. Only a single I/O adapter **320-321** may be connected to each terminal bridge **316-317**. Each of terminal bridges **316-317** is configured to prevent the

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propagation of errors up into the PCI Host Bridge **314** and into higher levels of data processing system **300**. By doing so, an error received by any of terminal bridges **316-317** is isolated from the shared buses **315** and **312** of the other I/O adapters **321**, **328-329**, and **336-337** that may be in different partitions. Therefore, an error occurring within an I/O device in one partition is not "seen" by the operating system of another partition. Thus, the integrity of the operating system in one partition is not effected by an error occurring in another logical partition. Without such isolation of errors, an error occurring within an I/O device of one partition may cause the operating systems or application programs of another partition to cease to operate or to cease to operate correctly.

Additional PCI host bridges **322**, **330**, and **340** provide interfaces for additional PCI buses **323**, **331**, and **341**. Each of additional PCI buses **323**, **331**, and **341** are connected to a plurality of terminal bridges **324-325**, **332-333**, and **342-343**, which are each connected to a PCI I/O adapter **328-329**, **336-337**, and **346-347** by a PCI bus **326-327**, **334-335**, and **344-345**. Thus, additional I/O devices, such as, for example, modems or network adapters may be supported through each of PCI I/O adapters **328-329**, **336-337**, and **346-347**. In this manner, server **300** allows connections to multiple network computers. A memory mapped graphics adapter **348** and hard disk **350** may also be connected to I/O bus **312** as depicted, either directly or indirectly. Hard disk **350** may be logically partitioned between various partitions without the need

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for additional hard disks. However, additional hard disks may be utilized if desired.

Those of ordinary skill in the art will appreciate that the hardware depicted in **Figure 3** may vary. For example, other peripheral devices, such as optical disk drives and the like, also may be used in addition to or in place of the hardware depicted. The depicted example is not meant to imply architectural limitations with respect to the present invention.

With reference now to **Figure 4**, a block diagram of an exemplary logically partitioned platform is depicted in which the present invention may be implemented. The hardware in logically partitioned platform **500** may be implemented as, for example, server **300** in **Figure 3**.

Logically partitioned platform **400** includes partitioned hardware **430**, hypervisor **410**, and operating systems **402-408**. Operating systems **402-408** may be multiple copies of a single operating system or multiple heterogeneous operating systems simultaneously run on platform **400**.

Partitioned hardware **430** includes a plurality of processors **432-438**, a plurality of system memory units **440-446**, a plurality of input/output (I/O) adapters **448-462**, and a storage unit **470**. Each of the processors **442-448**, memory units **440-446**, and I/O adapters **448-462** may be assigned to one of multiple partitions within logically partitioned platform **400**, each of which corresponds to one of operating systems **402-408**.

Hypervisor **410**, implemented as firmware, performs a number of functions and services for operating system

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images **402-408** to create and enforce the partitioning of logically partitioned platform **400**. Firmware is "hard software" stored in a memory chip that holds its content without electrical power, such as, for example, read-only
5 memory (ROM), programmable ROM (PROM), erasable programmable ROM (EPROM), electrically erasable programmable ROM (EEPROM), and non-volatile random access memory (non-volatile RAM).

Hypervisor **410** provides a secure direct memory
10 access (DMA) window, per IOA, such as, for example, IOA **328** in **Figure 3**, on a shared I/O bus, such as, for example, I/O bus **312** in **Figure 3**, into the memory resources allocated to its associated OS image, such as, for example, OS image **402** in **Figure 4**. In one
15 embodiment, as implemented within an RS/6000 Platform Architecture, the hypervisor makes use of two existing hardware mechanisms. These hardware mechanisms are called the translation control entry (TCE) facility and the DMA range register facility of an EADS PCI to PCI
20 bridge chip. In this embodiment, these two hardware mechanisms are placed under the control of the hypervisor.

When platform **400** is initialized, a disjoint range of I/O bus DMA addresses is assigned to each of IOAs
25 **448-462** for the exclusive use of the respective one of IOAs **448-462** by hypervisor **410**. Hypervisor **410** then configures the EADS range register (not shown) facility to enforce this exclusive use. Hypervisor **410** then communicates this allocation to the owning one of OS
30 images **402-408**. Hypervisor also initializes all entries in the IOA associated section of the TCE table to point

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to a reserved page per image that is owned by an OS image, such that unauthorized accesses to memory by one of OS images **402-408** will not corrupt or rob data from a neighboring one of OS images **402-408**.

5 When an owning one of OS images **402-408** requests to map some of its memory for a DMA operation, it makes a call to the hypervisor **410** including parameters indicating the IOA, the memory address range, and the associated I/O bus DMA address range to be mapped. The
10 hypervisor **410** checks that the IOA and the memory address range are allocated to the owning one of OS images **402-408**. The hypervisor **410** also checks that the I/O bus DMA range is within the range allocated to the IOA. If these checks are passed, the hypervisor **410** performs the
15 requested TCE mapping. If these checks are not passed, the hypervisor rejects the request.

 Hypervisor **410** also may provide the OS images **402-408** running in multiple logical partitions each a virtual copy of a console and operator panel. The
20 interface to the console is changed from an asynchronous teletype port device driver, as in the prior art, to a set of hypervisor firmware calls that emulate a port device driver. The hypervisor **410** encapsulates the data from the various OS images onto a message stream that is
25 transferred to a computer **480**, known as a hardware system console.

 Hardware system console **480** is connected directly to logically partitioned platform **400** as illustrated in **Figure 4**, or may be connected to logically partitioned
30 platform through a network, such as, for example, network

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102 in **Figure 1**. Hardware system console **480** may be, for example, a desktop or laptop computer, and may be implemented as data processing system **200** in **Figure 2**. Hardware system console **480** decodes the message stream and displays the information from the various OS images **402-408** in separate windows, at least one per OS image. Similarly, keyboard input information from the operator is packaged by the hardware system console, sent to logically partitioned platform **400** where it is decoded and delivered to the appropriate OS image via the hypervisor **410** emulated port device driver associated with the then active window on the hardware system console **480**.

In order to prevent instruction fetch errors in hypervisor **410** from affecting OS images **402-408** and the rest of platform **400**, two copies of the hypervisor **410** instructions are loaded into the memory of platform **400**. A hypervisor **410** instruction fetch error occurs when one of the processors **432-438** is executing hypervisor **410** instructions and, after fetching the next instruction from one of memories **440-446** containing the hypervisor **410** instructions, detects that there is an error in the instruction. For example, the error could be the result of the instruction having been stored in a bad memory location, such that the instruction has become corrupted. Such an error in the instruction results in a machine check interrupt and the processor, on occurrence of such an interrupt, is unable to determine what instruction it should execute next. In the prior art, such an occurrence would result in either a need to reboot the

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entire system, thus interfering with the continuous operation of OS images **402-408**, or extra redundancy bits for the entire system memory plus more complex encoding and decoding logic were utilized to recover from the error. Allowing for the necessity of rebooting the entire system could result in the loss of data for applications executing in one of OS images **402-408**, which is unacceptable and should be avoided if at all possible. Utilizing the extra redundancy bits along with more complex encoding and decoding logic impairs the speed and performance of platform **400**.

Hypervisor **410** also provides other functions and services to each of operating systems **402-408**. Some of these functions and services are not optional, such as the virtual console and operator panel described above. However, other services provided by the hypervisor **410** may be optional, allowing the platform administrator to make policy decisions with regard to options, that while generally useful, the administrator may wish to disable due to, for example, security concerns. Alternatively, optional features allow for expanded functionality over time, allowing new features to be introduced on new machines while the same operating system seamlessly runs on old machines without the new function.

Below, in **Table 1**, is an exemplary table of function sets and their mandatory/optional status. The hcall-pft functions manipulate the page frame table for processor virtual address translation the hcall-tce function set manipulates the Direct Memory Access (DMA) facilities used by the IO devices as described in U.S. Patent Application Serial Number _____ (IBM Docket No.

AUS990941US1) entitled "DMA Windowing" filed on _____.

The hcall sprg0, hcall-dabr and hcall-asr functions manipulate internal processor registers which may themselves be optional. The hcall-debug, & hcall-perf function sets provide services needed by debuggers and performance monitor routines. The hcall-term function set provides the function described in the virtual terminal invention disclosure. Finally hcall-dump provides facilities to allow an OS to do a dump of the Hypervisor data areas for platform debug.

	<u>Mandatory</u>	<u>Function Set</u>
15	Yes	hcall-pft
	Yes	hcall-tce
	Yes	hcall-sprg0
20	No - Only if DABR Exists	hcall-dabr
	Yes	hcall-copy
25	No - Only for Istar Processors	hcall-asr
	Yes	hcall-debug
	Yes	hcall-term
30	Yes	hcall-perf
	No - Only if enabled by HSC (default disabled)	hcall-dump

35 To make certain features available, hypervisor **410** provides a list of function sets. Each function set includes one or more hypervisor function calls. Once a function set has been selected by platform **400**, all

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function calls contained within the function set must be made available to each of OSs **402-408**.

In one embodiment, the OS is made aware of the services in the function set by being passed a parameter
5 called a "property" in a structure that it receives at boot time. This property contains the list of the function set names, outlined above, that are available for it to use. The OS is expected to only make those requests that are specified in the property list,
10 however, if the OS should make some other call that is not specified as being supported, the hypervisor will return an error message to the OS.

As a new service or function call for hypervisor **410** is provided, a system architect adds these new services
15 and function calls to a new function set to include the newly available services and function calls. This is typically performed by the vendor prior to delivering a new updated hypervisor version to a platform.

Those of ordinary skill in the art will appreciate
20 that the hardware and software depicted in **Figure 4** may vary. For example, more or fewer processors and/or more or fewer operating system images may be used than those depicted in **Figure 4**. The depicted example is not meant to imply architectural limitations with respect to the
25 present invention.

With reference now to **Figure 5**, an exemplary hypervisor function set table is depicted in accordance with the present invention. Hypervisor function set table **500** includes a plurality of function sets **501-510**
30 under a heading of "function set names" **520**. Each of function sets **501-510** contains a list of hypervisor

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function calls under the heading of "functions" 530
available within that particular one of function sets
501-510.

With reference now to **Figure 6**, a flowchart
5 illustrating an exemplary process for providing an
operating system with a list of hypervisor function calls
available on a platform is depicted in accordance with
the present invention. To begin, the hypervisor, such as
hypervisor 410 in **Figure 4**, receives a request to
10 configure the hypervisor function calls for the platform,
such as, for example, platform 400 (step 602). The
hypervisor presents the user (typically the system
administrator), such as through a window display on
hardware system console 480 in **Figure 4**, with a list of
15 function set options available (step 604). The available
function sets may be Function Sets 501-510 depicted in
Figure 5. In one embodiment, the displayed list may
contain only the function set names with additional
information about each function set available through a
20 selectable hyperlink. In another embodiment, the list
may contain the name of each function set along with
information detailing the differences between the
function set, but not displaying each function call
available with each particular function set. In yet
25 another embodiment, the entire function call list for
each function set may be displayed to the user.

Once the user has selected a function set for use
with the platform, the hypervisor receives the user
selected option (step 606) and stores the selection (step
30 608) in a storage device within the platform, such as,
for example, hard disk 350 in **Figure 3**. Each time a new

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operating system image is started on the platform, the hypervisor provides the newly started OS image with the user selected function set, which includes a list of available hypervisor function calls enabled for the OS
5 image (step **610**).

With reference now to **Figure 7**, a flowchart illustrating an exemplary method for updating a list of function sets within a platform is depicted in accordance with the present invention. To update a list of function
10 sets with newly introduced function sets, a new version of the hypervisor firmware is loaded onto the platform (step **702**). The platform is then rebooted (step **704**) and the hypervisor reports any new function sets it may support to the OSs on this OS boot (step **706**). An old
15 level of an OS that does not understand how to use the new function set will ignore it and use the same subset of the hypervisor's functions that it did prior to the update. A newer level of OS that had been capable of using the new function but had been restricted by a lack
20 of hypervisor firmware support in the old level of the hypervisor will, after the update, see the availability of the new functions and proceed to use them.

It is important to note that while the present invention has been described in the context of a fully
25 functioning data processing system, those of ordinary skill in the art will appreciate that the processes of the present invention are capable of being distributed in the form of a computer readable medium of instructions and a variety of forms and that the present invention
30 applies equally regardless of the particular type of signal bearing media actually used to carry out the

distribution. Examples of computer readable media include recordable-type media such as a floppy disc, a hard disk drive, a RAM, and CD-ROMs and transmission-type media such as digital and analog communications links.

5 The description of the present invention has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. The embodiment was chosen and described in order to best explain the principles of the invention, the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are
10 suited to the particular use contemplated.
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CLAIMS:

5 What is claimed is:

1. A logically partitioned data processing system,
comprising:

10 a plurality of operating systems, each assigned to a
separate one of a plurality of logical partitions;

a hypervisor for creating and enforcing separation
between each of the plurality of logical partitions;
wherein

15 the hypervisor includes a plurality of functions
sets, each function set including a list of functions
which may be called by any one of the plurality of
operating systems to perform a task while maintaining
separation between each of the plurality of logical
partitions,

20 the hypervisor informs each of the plurality of
operating systems of an enabled function set, wherein
functions identified within the enabled function set are
enabled for use by each of the plurality of operating
systems and functions not identified within the enabled
25 function set are disabled for use by each of the
plurality of operating systems.

2. The logically partitioned data processing system as
recited in claim 1, wherein the enabled function set from
30 the plurality of function sets may be changed such that a
different one of the plurality of function sets becomes

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the enabled function set.

3. The logically partitioned data processing system as recited in claim 1, wherein additional function sets may be added to the plurality of function sets as additional functions are added to the plurality of functions provided by the hypervisor.

4. The logically partitioned data processing system as
10 recited in claim 1, wherein the hypervisor is implemented
as firmware.

5. The logically partitioned data processing system as recited in claim 1, wherein each of the plurality of function sets comprises a different group of the plurality of functions.

6. The logically partitioned data processing system as recited in claim 1, wherein optional functions are omitted from at least one of the plurality of function sets.

7. A method of configuring a set of services provided by a hypervisor to a logically partitioned data processing system, the method comprising:

presenting a user with a set of service options, wherein the set of service options correspond to services performed by the hypervisor for each of multiple operating systems within the logically partitioned data processing system such that processes performed by one of the multiple operating systems do not interfere with

processes performed by others of the multiple operating systems;

5 presenting the service option to an operating system
image as the operating system image is initialized.

8. The method as recited in claim 7, further comprising:

responsive to loading a new version of the hypervisor, wherein the new version of the hypervisor contains additional services, reporting the additional services to each operating system upon re-initialization.

15 9. The method as recited in claim 7, wherein the
operating system image is initialized by booting.

10. The method as recited in claim 8, wherein the
re-initialization of each operating system is performed
20 by a reboot.

11. The method as recited in claim 7, wherein the hypervisor is implemented as firmware.

25 12. The method as recited in claim 7, wherein the set of services comprise a table of function sets and each of the function sets, upon selection, enables a subset of functions, provided by the hypervisor, for use by each of the multiple operating systems.

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13. A computer program product in a computer readable

media for use in a data processing system for configuring a set of services provided by a hypervisor to a logically partitioned data processing system, the computer program product comprising:

second instructions, responsive to selection of a particular service option, for storing the selected service option and presenting the service option to an operating system image as the operating system image is initialized.

third instructions, responsive to loading a new version of the hypervisor, wherein the new version of the hypervisor contains additional services, for reporting the additional services to each operating system upon re-initialization.

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16. The computer program product as recited in claim 14,

wherein the re-initialization of each operating system is performed by a reboot.

18. The computer program product as recited in claim 13, wherein the set of services comprise a table of function sets and each of the function sets, upon selection, enables a subset of functions, provided by the hypervisor, for use by each of the multiple operating systems.

first means for presenting a user with a set of service options, wherein the set of service options correspond to services performed by the hypervisor for each of multiple operating systems within the logically partitioned data processing system such that processes performed by one of the multiple operating systems do not interfere with processes performed by others of the multiple operating systems; and

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20. The system as recited in claim 19, further

comprising:

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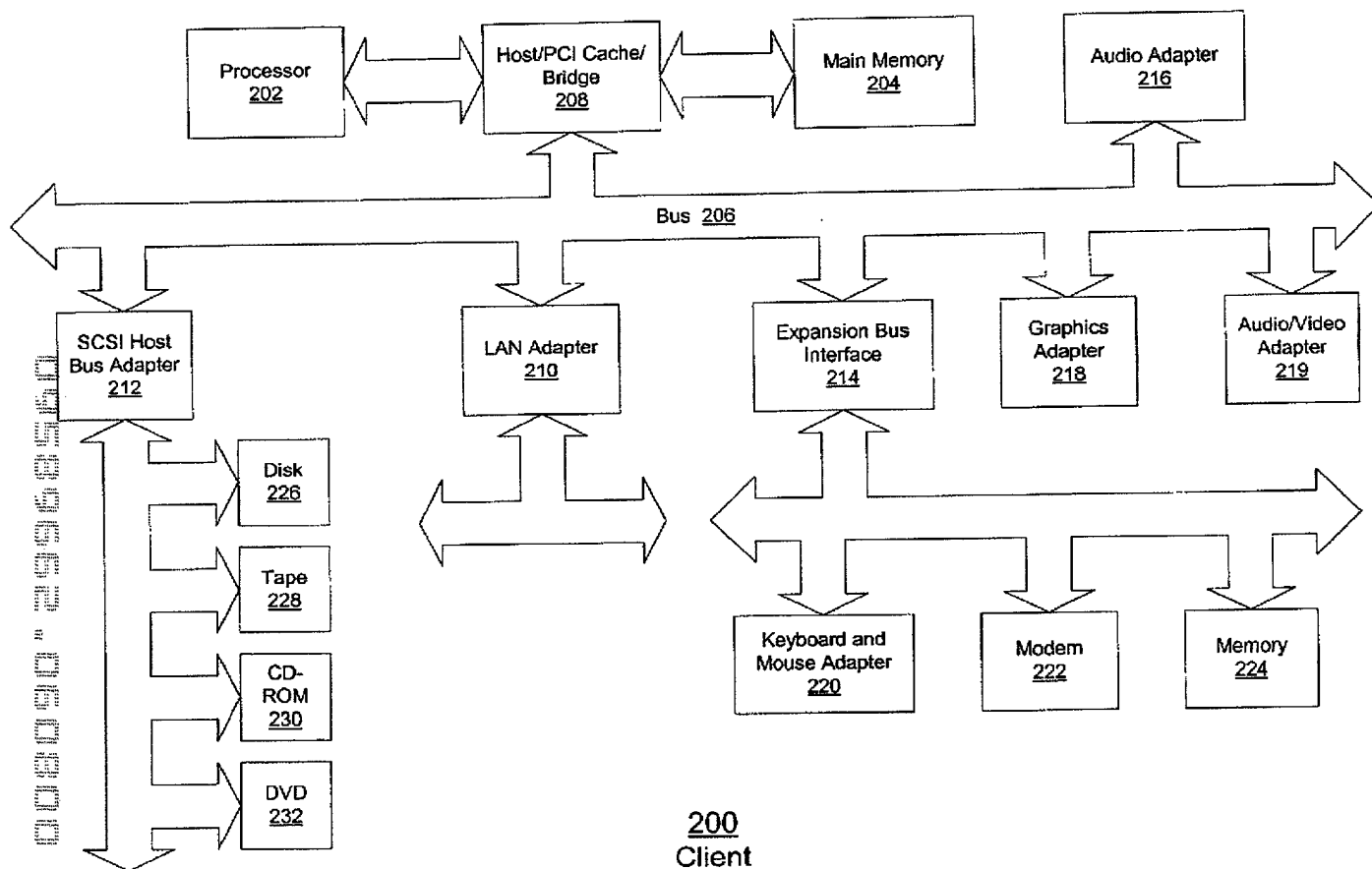
24. The system as recited in claim 19, wherein the set of services comprise a table of function sets and each of the function sets, upon selection, enables a subset of functions, provided by the hypervisor, for use by each of the multiple operating systems.

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ABSTRACT OF THE DISCLOSURE

HYPERVISOR FUNCTION SETS

5 A method, system, and apparatus for informing a plurality of operating systems, each assigned to a separate partition within a logically partitioned data processing system, of which functions, provided by a hypervisor for creating and enforcing separation of the logical partitions, are available for use by the operating systems is provided. In a preferred embodiment, the hypervisor includes a plurality of function sets. Each function set includes a list of functions that may be called by any one of the operating systems to perform tasks for the operating systems while maintaining separation between each of the logical partitions. The hypervisor informs each of the plurality of operating systems of an enabled function set. Functions identified within the enabled function set are enabled for use by each of the plurality of operating systems and functions not identified within the enabled function set are disabled for use by each of the plurality of operating systems.



200
Client
Figure 2
AUS990939US1

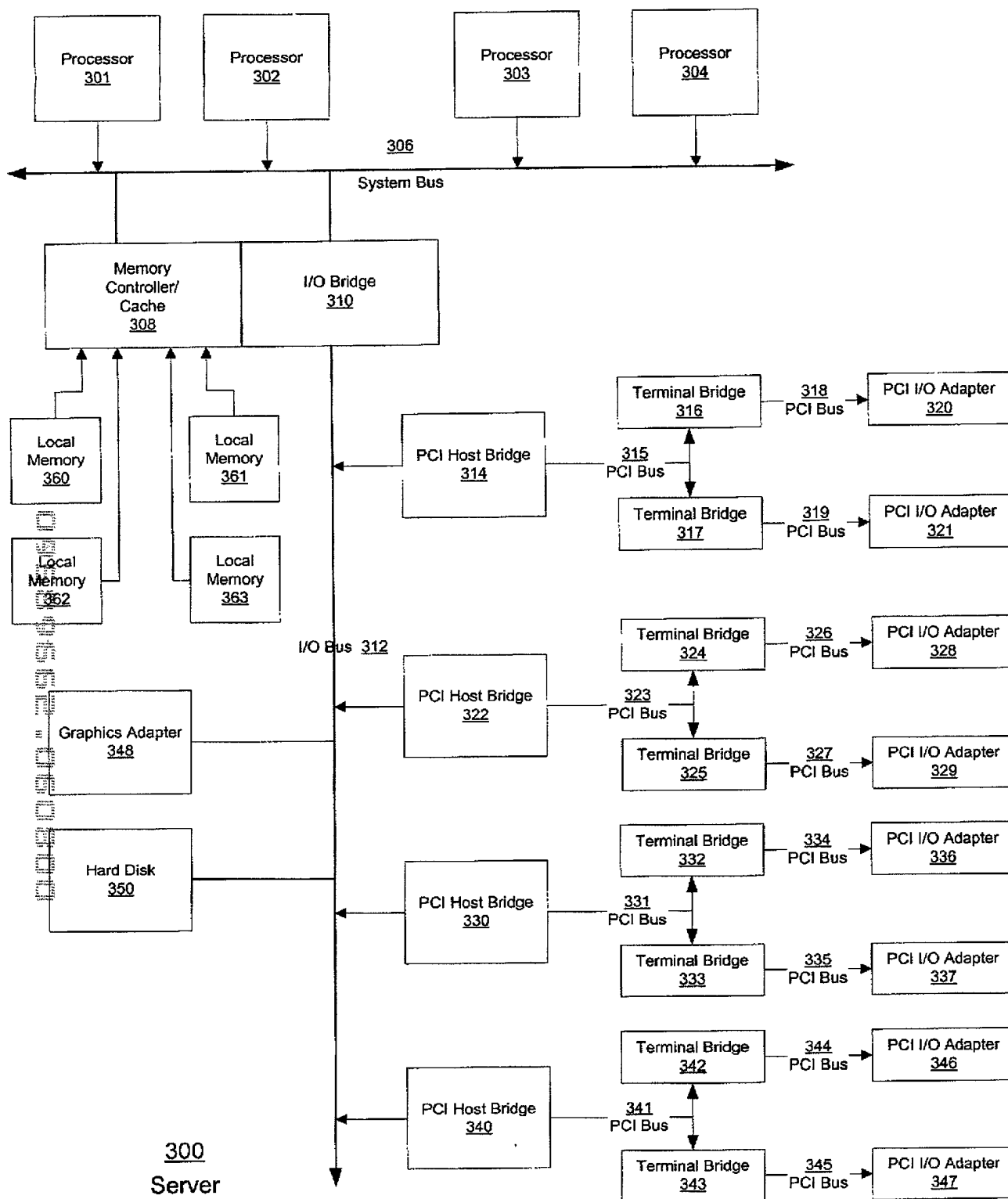


Figure 3

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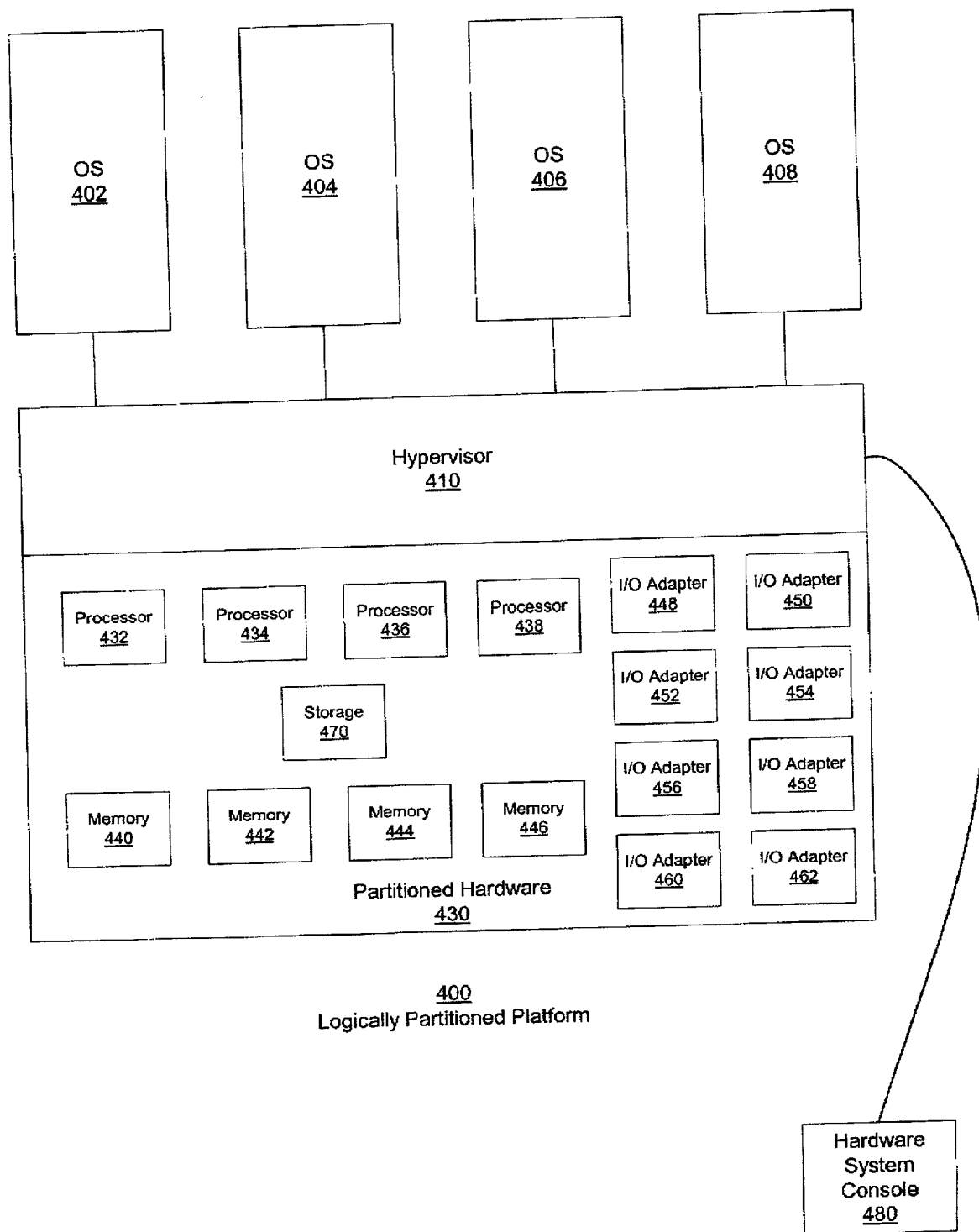


Figure 4
AUS990939US1

Function Set Name:	Functions
501 hcall-pft	H_REMOVE, H_ENTER, H_READ, H_CLEAR_MOD, H_CLEAR_REF, H_PROTECT
502 hcall-tce	H_GET_TCE, H_PUT_TCE
503 hcall-sprg0	H_SET_SPRG0
504 hcall-dabr	H_SET_DABR
505 hcall-copy	H_PAGE_INIT
506 hcall-asr	H_SET_ASR, H_ASR_ON, H_ASR_OFF
507 hcall-debug	H_LOGICAL_CI_LOAD, H_LOGICAL_CI_STORE, H_LOGICAL_CACHE_LOAD, H_LOGICAL_CACHE_STORE, H_LOGICAL_ICBI, H_LOGICAL_DCBF
508 hcall-term	H_GET_TERM_CHAR, H_PUT_TERM_CHAR
509 hcall-perf	H_REAL_TO_LOGICAL
510 hcall-dump	H_HYPERVISOR_DATA

Hypervisor Function Set Table
500

Figure 5
AUS990939US1

1. General Information	
Project Name:	...
Project Number:	...
Project Manager:	...
Project Start Date:	...
Project End Date:	...
Project Status:	...
Project Description:	...
Project Objectives:	...
Project Scope:	...
Project Budget:	...
Project Risk:	...
Project Impact:	...
Project Stakeholders:	...
Project Sponsor:	...
Project Steering Committee:	...
Project Governance:	...
Project Communication:	...
Project Reporting:	...
Project Documentation:	...
Project Change Management:	...
Project Configuration Management:	...
Project Quality Management:	...
Project Risk Management:	...
Project Resource Management:	...
Project Time Management:	...
Project Cost Management:	...
Project Procurement Management:	...
Project Stakeholder Management:	...
Project Integration Management:	...
Project Performance Management:	...
Project Compliance Management:	...
Project Security Management:	...
Project Environmental Management:	...
Project Social Management:	...
Project Governance Management:	...
Project Ethics Management:	...
Project Sustainability Management:	...
Project Innovation Management:	...
Project Knowledge Management:	...
Project Learning Management:	...
Project Improvement Management:	...
Project Success Management:	...

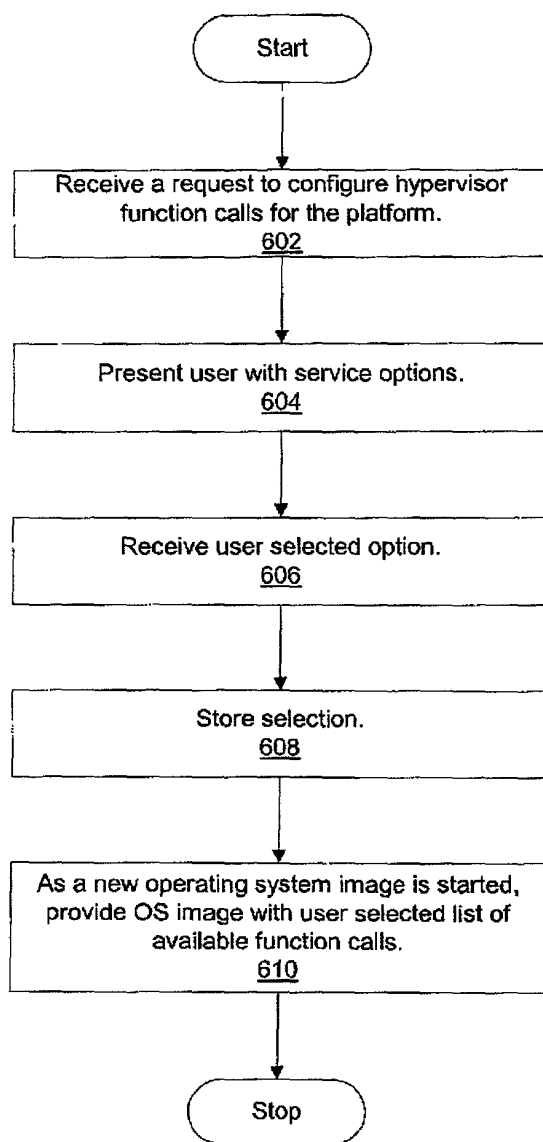


Figure 6

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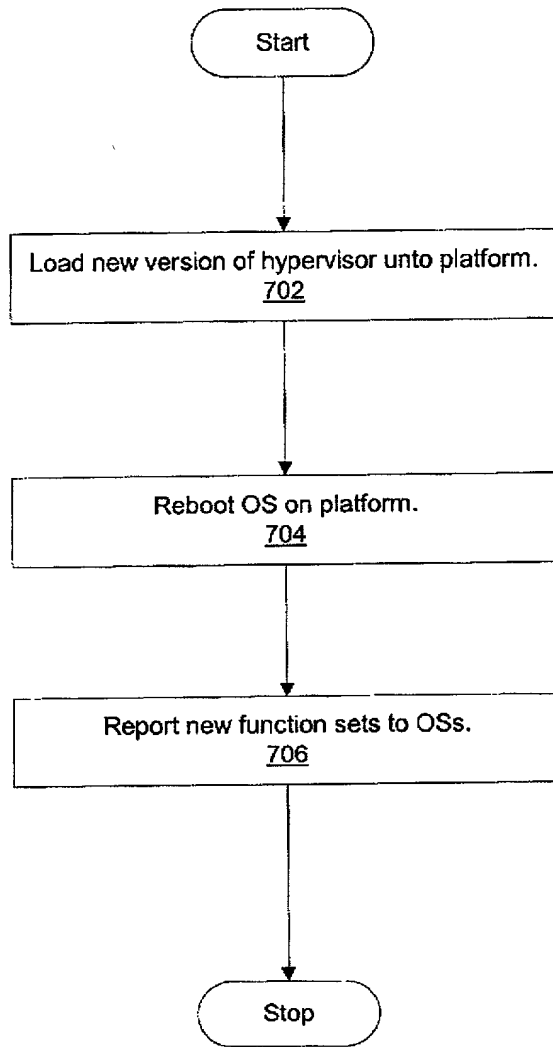


Figure 7

AUS990939US1

**DECLARATION AND POWER OF ATTORNEY FOR
PATENT APPLICATION**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

HYPERVERSITOR FUNCTION SETS

the specification of which (check one)

X is attached hereto.

___ was filed on _____
as Application Serial No. _____
and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s): Priority Claimed

____ Yes ____ No
(Number) (Country) (Day/Month/Year)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information material to the patentability of this application as defined in Title 37, Code of Federal Regulations, §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial #) (Filing Date) (Status)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorneys and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

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INVENTORS SIGNATURE: Richard Louis Arndt DATE: 1 June 2000

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